5

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Two years ago Dr. Hatai ('09) called attention to the fact that the central nervous system in the Norway rat, Mus norvegicus, was distinctly heavier than that in the albino rat, which is a strain derived from the Norway, Hatai ('07).

Thus in animals of the same body weight, both the brain and the spinal cord of the Norway was found to be heavier than in the corresponding albino.

In view of Darwin's observations ('83) on the diminution in skull capacity in domesticated strains and of Lapicque and Girard's observations ('07) on the diminution of brain weight under the same conditions, it seemed probable that we had in the case of the albino rat, which only thrives in captivity, but another example of the effects of domestication on the development of the central nervous system.

Under these circumstances it appeared worth while to determine if possible just what factors in domestication brought about this result.

For this purpose we have attempted to analyze the condition of domestication into its elements with a view to testing these one by one.

On considering the differences in the mode of life between the wild gray rat and the captive albino, it became apparent for one thing that in a general way the albino took less exercise than the wild form. The diminution in the amount of exercise is then one of the several factors possibly contributing to the difference. The present experiments were undertaken therefore

to see whether if they were given more exercise, the albinos would improve in respect to the weight of their central nervous system. All the other conditions of course were kept constant.

The opportunity for exercise was given by housing the rats to be tested in revolving cages. In these cages the nesting box, food and water are hung from a fixed horizontal axle around which a cylindrical cage is placed so as to revolve readily. In such a cage the rats often run voluntarily for long periods. This form of cage was that used by Slonaker ('07) in his studies on the daily activity of the rat, and he found from the records kept for several years that during the time of greatest activity the rats ran often many miles during the night. Further, they established a good rhythm of living, remaining quiet during the day and becoming active at night.

In the present instance, no record has been kept of the actual distance traversed by the various rats. A visit during the evening to the room where these animals were kept, and where the revolving cages were in active use, indicated however that they were taking a very considerable amount of exercise.

The assumption therefore is justified that the rats in revolving cages were taking much more exercise than their brothers and sisters, used as controls, and kept in the standard cages, about one foot in cross section and five feet long, which are generally used in the rat room.

The following observations bear on only one aspect of the question, namely: the influence of exercise on the central nervous system of individuals placed in the cages after they had reached about 30 days of age, the period at which it can be seen by referring to my studies on the growth of the brain in the rat, Donaldson ('08), that the brain has attained about two-thirds of its final weight and the spinal cord about one-third.

The attempt therefore is here made to influence a nervous system rather well advanced in its growth.

At the present time it is possible to report on two series of observations, one completed in February, 1910, and the other in October, 1910. Both apply to rats which had been put in the revolving cages when they were about one month old and killed when they

were between seven and eight months old. Each individual in the revolving cage is represented by one or more individuals, of the same sex and of the same litter, which were grown in the ordinary cages standing beside the revolving cages. Both sets of animals were fed in the same way. If any differences occur among the rats in the revolving cages, these therefore may be fairly referred to the exercise which they took under the conditions named.

In the first set of experiments there were three groups involved, the rats being all males and there being in all ten exercised and nine control individuals.

In the October series of observations, there were eight litters from which males alone were used and six litters from which the females alone were used, representing in all fourteen exercised and twenty-two control rats.

The February series and the October series have been considered separately and found to agree in four points, namely:

1. In the exercised rats the body length is slightly less than in the controls. This occurs in 17 out of a total of 23 contrasted pairs, *i.e.*, in 74 per cent.

2. In both series the brain weight is slightly higher in the exercised rats. This occurs in 17 out of a total of 23 contrasted pairs, *i.e.*, in 74 per cent. In the February series the brain weight surpasses that of the controls by 2.4 per cent, and in the October series by 2.7 per cent.

3. The weight of the cord on the contrary is not apparently influenced by exercise, but is slightly lower in the exercised rats, following probably the smaller body length. This is an unexpected result.

4. Finally, the percentage of water in the brains of the exercised rats is the same as that in the brains of the controls. Although in the spinal cord there is 0.31 per cent less water in the cord of the exercised rats in the February series, there is in the October series a difference of .034 per cent in the opposite direction, so that I hardly think that this difference is of any significance, and we may consider the percentage of water in the spinal cord as uninfluenced by exercise.

The relation of body weight to body length shows a difference between the exercised and controls, but in the February series the controls are 2.5 per cent higher, and in the October series the exercised are 5.5 per cent higher. This relation therefore does not appear to be influenced.

The following tables with the explanations which go with them will indicate the basis for the statements which have just been given. The construction of the tables is as follows:

The average values for any group or series are compared with standard values—based on the same body length (see line marked "standard values"). The body length has been selected for this purpose because it is not subject to the rapid fluctuations which may affect body weight, and also because it is highly correlated with the brain weight and the spinal cord weight, as well as the weight of the body (Donaldson, '09, p. 166). The difference between the standard values and those observed is then expressed in percentages of the standards (see line marked "percentages").

Thus in table 1, series 2, 4 and 5, the exercised rats have an average body length of 197 mm. and an average body weight of 201 gms. For the body length of these series the standard body weight is 184.3 gms. and the difference between this value and that observed amounts to +9 per cent of the standard. This difference is written with a plus sign before it to show that the observed body weight in this case is 9 per cent in excess of the standard.

When the average for the controls in the same series is treated in a like manner, it is found that the observed values are here 10 per cent greater than the standard.

If now we compare the deviation from the standard in the exercised with that in the controls, it is evident that the deviation in the exercised is the smaller, or minus 1 per cent as shown in the last line of the table.

The exercised rats have therefore bodies which are 1 per cent lighter than the controls when compared with the corresponding standards.

TABLE 1

SUMMARY OF FEBRUARY SERIES, 1910

Exercised rats, Males 10

AGE	SERIES	BODY LENGTH	BODY WEIGHT	BRAIN WEIGHT	CORD WEIGHT	PER CENT OF WATER IN	
						Brain	Cord
days		*mm.*	*gms.*	*gms.*	*gms.*		
213	2 (3)	205	214.9	2.1437	.6492		
225	4 (3)	194	195.3	1.8695	.5372		
227	5 (4)	192	192.8	1.9342	.5437		
Average		197	201.0	1.9825	.5767	78.514	71.886
Standard values		197	184.3	1.8448	.5522		
Differences absolute			16.7	.1377	.0245		
Percentage			+9.0	+7.4	+4.4		

Control rats, Males 9

AGE	SERIES	BODY LENGTH	BODY WEIGHT	BRAIN WEIGHT	CORD WEIGHT	PER CENT OF WATER IN	
						Brain	Cord
days		*mm.*	*gms.*	*gms.*	*gms.*		
213	2 (3)	217	254.6	2.1312	.6782		
225	4 (3)	194	201.8	1.8354	.5591		
227	5 (3)	194	205.9	1.9144	.5569		
Average		202	220.8	1.9603	.5981	78.517	72.203
Standard values		202	200.8	1.8671	.5717		
Differences absolute			20.0	.0932	.0264		
Percentage			+10	+4.9	+4.6		
Exercised rats differ from controls by			−1%	+2.5%	−0.2%	−.003%	−.317%

TABLE 2

SUMMARY OF OCTOBER SERIES, 1910

Exercised rats, Males 8

AGE	BODY LENGTH	BODY WEIGHT	BRAIN WEIGHT	CORD WEIGHT	PER CENT OF WATER IN	
					Brain	Cord
days 231	*mm.* 203	*gms.* 217.5	*gms.* 1.9770	*gms.* .5975	78.372	70.961
Standard values...	203	204.3	1.8716	.5755		
Differences absolute...		13.2	.1054	.0220		
Percentage		+6.4	+5.6	+3.8		

Control rats, Males 12

AGE	BODY LENGTH	BODY WEIGHT	BRAIN WEIGHT	CORD WEIGHT	PER CENT OF WATER IN	
					Brain	Cord
days 228	*mm.* 206	*gms.* 222	*gms.* 1.9441	*gms.* .6185	78.317	70.978
Standard values...	206	215	1.8849	.5872		
Differences absolute...		7	.0592	.0313		
Percentage		+3.2	+3.1	+5.3		
Exercised male rats differ from male controls by............		+3.2%	+2.5%	−1.5%	+.055%	−.017%

TABLE 2 (*Continued*).

SUMMARY OF OCTOBER SERIES, 1910

Exercised rats, Females 6

AGE	BODY LENGTH	BODY WEIGHT	BRAIN WEIGHT	CORD WEIGHT	PER CENT OF WATER IN	
					Brain	Cord
days 243	*mm.* 186	*gms.* 160	*gms.* 1.8928	*gms.* .5659	78.471	71.251
Standard values...	186	152.3	1.7946	.5095		
Differences absolute..		7.7	.0982	.0564		
Percentage		+5.0	+5.4	+11.0		

Control rats, Females 10

AGE	BODY LENGTH	BODY WEIGHT	BRAIN WEIGHT	CORD WEIGHT	PER CENT OF WATER IN	
					Brain	Cord
days 243	*mm.* 189	*gms.* 155.9	*gms.* 1.8553	*gms.* .5736	78.390	71.172
Standard values...	189	160.5	1.8084	.5212		
Differences absolute....		−4.6	+.0469	+.0524		
Percentage		−2.8	+2.5	+10.0		
Exercised female rats differ from controls by		+7.8%	+2.9%	+1%	+.081	+.079
Averaging the data for males and females in this series, the exercised rats differ from the controls by		+5.5%	+2.7%	−0.25%	+.068%	+.031%

This same method of comparison has been carried through for both the brain weight and spinal cord weight. As regards the percentage of water, the reference to a standard is not necessary since this character is closely correlated with age, and the ages of the series compared are alike; hence the determinations for the percentage of water can be directly compared with one another.

It remains merely to explain what is meant by the term "standard values."

Using the data which already have been published on body weight, brain weight, spinal cord weight and body length, Donaldson ('08), Donaldson ('09), and employing the formulas worked out by Dr. Hatai ('09), it had been possible to form a detailed table based on the body length and giving for each millimeter of body length, the corresponding weights for body, brain and spinal cord, both in males and in females. These data form convenient standards based on the least variable character, *i.e.*, body length, to which any new series of observations may be referred and are especially useful in a case like the present, where in the absence of such a standard one of the series would necessarily need to be used as a basis for determining the variation of the other—an operation which it is difficult to carry through with any degree of consistency.

It follows from the foregoing observations, so far as the nervous system is concerned, that there is a slight improvement (2.4 – 2.7 per cent) in the weight of the brain caused by giving the rats the opportunity for exercise, even when this opportunity comes only after the larger part of the growth of the brain has been accomplished.

On the other hand, the spinal cord does not appear to be affected.

If exercise can influence the weight of the nervous system, it seems probable that its effects can be best studied in animals grown for several generations under the conditions here described. Later we hope to study animals thus grown, as it has already been found that rats can breed in these revolving cages and bring up their young in them without difficulty.

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